Influence of Job Market Conditions on Engineering Cooperative Education Participation

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Abstract: Cooperative education (co-op) is a program in which participating students typically alternate between full-time study and paid full-time employment. Choosing to participate in a co-op program usually delays the student's graduation by up to one year, but may increase the student's job market prospects. This paper attempts to estimate the response of co-op participation to the engineering field-specific average wage for recent graduates. A relationship between wage growth, student ability, and co-op participation is investigated. Predictive modeling was performed using data obtained from the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD), as well as the American Association of Engineering Societies (AAES) *Annual Report of Engineering Salaries*. Semi-structured interviews were conducted with industry co-op representatives to address supply and demand related questions. The authors found that a \$10,000 real increase in the average initial wage causes a 5.4% decrease in co-op program participation. In addition, there is heterogeneity in the response by student ability. **DOI: 10.1061/(ASCE)EI.1943-5541.0000270.**

Author keywords: Cooperative education; Predictive modeling; Student ability; Wage rate.

Introduction

A cooperative education (co-op) program is a partnership between an academic institution, students, and firms in which participating students typically alternate between periods of full-time study and paid full-time employment. While variations do exist, in engineering it is fairly common for a co-op program to involve three nonsequential semesters of paid employment off campus with the same firm. The hiring firm pays the participating students a field-specific rate. Students may apply for a co-op position once they have completed all the core/introductory engineering courses and selected the engineering field in which they will major. Most institutions do not offer academic credit for employment semesters and do not reduce any requirements for graduation. Thus, choosing to participate in a co-op program usually extends the standard four-year undergraduate degree by one additional year.

Even though it delays graduation by a year, co-op programs are popular in engineering schools, with about one quarter of eligible students choosing to participate. Wages during the alternating semesters of employment are commonly in the \$12 to \$20/h range, depending on the field and university, and provide an important incentive for participation. In addition, students anticipate that co-op participation will provide them with practical on-the-job engineering experience during the periods of paid employment that may be valued by potential employers and increase their likelihood of finding a good job after graduation. There is evidence that co-op participants are more likely to be employed soon after graduation and have higher initial wages than other engineering graduates (Somers 1995).

The percentage of students that choose to participate in a co-op varies substantially with time and by discipline. Fig. 1 illustrates this by plotting the rate of co-op participation from 1989 to 2003 in four selected engineering fields (disaggregated) at the seven academic institutions considered in this study (aggregated). The academic institutions are Clemson University, Florida A&M University, Florida State University, North Carolina State University, Purdue University, University of Florida, and Virginia Tech. Students with less than a 2.5 freshman-year grade-point average (GPA) are excluded from the figure because the participating academic institutions generally set a minimum GPA requirement for participation in a co-op program. At all seven academic institutions, co-op is an option and not a requirement for graduation.

While exceptions to the policy are sometimes granted, there is little participation by students with less than a 2.5 freshman-year GPA. The participation rates for chemical and electrical engineers are much higher than those for civil engineers though they seem to have trended downward during the late 1990s and early 2000s. Meanwhile participation rates for civil engineers remained fairly steady. Understanding why co-op participation rates change over time is important to the academic institutions and employers who use co-op programs. There are some firms that make a large fraction of their hires each year directly from a co-op program, so changes in the number of participating students can influence the labor market for new engineers.

Of particular importance is the fact that participation in a co-op program is a significant within-major human capital investment made during college. Documenting the characteristics of students who choose to make this additional human capital investment and analyzing how economic factors influence that choice leads to a better understanding of the link between educational choices and labor market outcomes. In this paper, the authors focus on understanding how engineering co-op program participation responds to field-specific job market conditions and document heterogeneity in this response by students of different ability.

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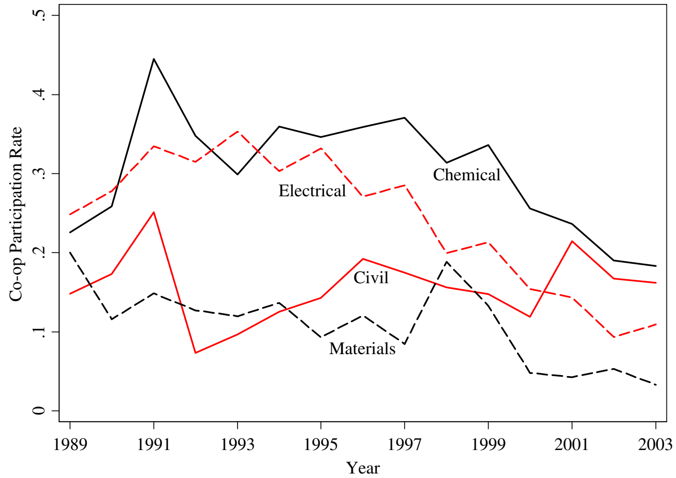

Fig. 1. Selected co-op participation rates by year (Note: The data include students with a 2.5 freshman-year GPA or higher that have declared a major in chemical, electrical, civil, or materials engineering by the first semester of their sophomore year at Clemson, Florida A&M, Florida State, North Carolina State, Purdue, Florida, and Virginia Tech)

This study specifically investigated the following research questions:

- What relationship exists between student ability and participation in a cooperative education program?
- How does potential future permanent wage rate influence participation in a cooperative education program?
- How does wage growth influence participation in a cooperative education program?

This study begins with a brief summary of the literature on co-op participation and describes the characteristics of co-op programs. The next section describes the student data and the engineering wage data used in the study. The following section presents the theoretical and empirical models of co-op participation, as well as a description of the interviews conducted with co-op employers. Results and conclusions are presented thereafter.

Cooperative Education in Engineering Literature

Cooperative education is the general name used to describe paid, full-time, temporary, career-related employment associated with college-level education. The term cooperative education, or co-op, is often used interchangeably with work-integrated learning, experiential learning, and professional practice. A co-op program in engineering is a partnership between an academic institution, a student, and an employer designed to combine practical engineering experience during the periods of paid full-time employment with traditional classroom training during the periods of full-time study. The concept was first developed in 1901 by Herman Schneider, an engineering professor at Lehigh University (Russell 1991; Smollins 1999; Stockbridge 1911). Schneider surveyed Lehigh University engineering graduates and noted that those individuals who had practical experience prior to graduation were more successful in their careers than their peers with no pre-graduation experience. He started the first co-op program in 1906 after relocating to the University of Cincinnati. Other academic institutions created similar programs, and by 1962 there were 150 co-op programs in the United States (Stockbridge 1911). As of 1996, the final printing of the Directory of College Cooperative Education (DCCE) reports that the number of co-op programs had grown to 460 across a wide variety of institutions and academic majors (National Commission for Cooperative Education 1996). The DCCE estimates that approximately 50,000 employers participate in co-op programs, including 85% of the top 100 companies on the Fortune 500 List.

The most common path into an engineering co-op program is for an interested student to apply for a co-op position during sophomore year after having selected a major and completed the core/introductory engineering courses. In addition to course requirements, many universities also require a minimum GPA for co-op participation. Employers advertise co-op position openings through the university co-op office, which facilitates the matching process. Co-op program administrators continuously work to maintain or enlarge their pool of students and employers.

Commonly, students are provided with a list of co-op positions and then decide which listing(s) to respond to with a resume. Program administrators prescreen the student resumes to ensure eligibility before providing them to the prospective employer. Eligibility requirements are specific to the academic institution and in some cases are left to the discretion of individual academic departments. For example, Clemson University currently requires a minimum 2.5 grade-point average and completion of all freshman course requirements (Clemson University 2015), while Virginia Tech currently allows individual engineering departments to define eligibility (Virginia Tech 2015). Employers identify students they are interested in meeting with and interviews are generally performed on-campus in space provided by the co-op program office. The employer is not obligated to hire any students. Students are also free to pursue co-op employment with companies not officially listed with the program office, though the agreement must be officially registered with the co-op program office to ensure that the student receives credit towards program completion. In a voluntary co-op program, once students choose to participate, they make a professional commitment to complete the program. At many academic institutions, completing the program earns a student special recognition on their transcript. Failure to complete the program could significantly decrease the student's chances of securing a job with their co-op employer.

Though most co-op placement occurs within the region immediately surrounding the academic institution, the universities in the sample routinely place students throughout the United States and Europe. For example, Purdue University places 40% of their co-op students outside the midwestern United States (Purdue University 2015). Once matched with a co-op employer, students will generally alternate between semester-long periods of on-campus academic study and three semester-long periods of off-campus full-time employment. Formal engineering co-op programs must require at least 52 weeks of full-time practical experience in order to be accredited (ABET 2014). These non-sequential semesters of full-time employment are generally with the same firm and are distributed across the spring, summer, and fall terms. Inevitably, choosing to engage in a co-op program extends the standard four-year undergraduate degree by one additional year.

The co-op employer pays the participating students a field-specific hourly wage. There is typically little opportunity for wage negotiation between the student and the firm. Because the hourly wage is better than most available on-campus employment, participating in a co-op program may be the means by which many participating students choose to finance a portion of their college education as they can use the income from full-time paid employment semesters to pay expenses during full-time study semesters.

Upon graduation, many students that participated in the co-op program are offered full-time employment by their co-op employer. In a survey of co-op students in the North Carolina community college system, Wessels and Pumphrey (1995) report that 40% of co-op participants accept permanent employment offers from their co-op employer. In a survey of Texas co-op employers, Friel (1995) reports that 53% of co-op participants accept permanent employment offers from their co-op employer. Even if this offer is not ultimately accepted, it may increase the student's bargaining power with other potential employers, which could lead to a higher wage.

As mentioned in the "Introduction" section, Somers (1995) concludes that co-op participants are more likely to be employed soon after graduation and have higher starting salaries than nonparticipants, though this may be due to student selection into co-op programs rather than the causal effect of the co-op program. In a subsequent survey of 600 engineering students from a large public university, Gardner and Motschenbacher (1997) confirm that co-op participants have higher starting salaries on average, but find that the salary difference declines over time, with no differences in later career outcomes. This suggests that the initial increase in wages and employment probability are not driven by selection, though it does not rule out selection on factors that influence initial wages but have little effect on later career outcomes.

In addition to receiving pay while in college and possible employment advantages after graduation, the literature on engineering co-op programs has identified other benefits including improved academic performance, self-efficacy, confirmation of career choice, and increased networking that may influence student participation (Calway and Murphy Gerald 2000; Gardner and Motschenbacher 1997; Morgan et al. 1999; Raelin et al. 2011; Somers 1995; Worley 2010). Across all co-op programs, the university makes efforts to ensure that the nature of the work asked of the students is realistic and nonmenial. Co-op students engage in real jobs and function as viable, paid employees of the company.

There is a large volume of literature showing that student occupational or career choice responds to job market conditions. Focus on students' decisions to study engineering began with work by Arrow and Capron (1959) and Hansen (1961) during a period when there was concern about a shortage of engineers. These and later studies found that student enrollment in engineering is sensitive to wages paid in the engineering profession. More recently, Ryoo and Rosen (2004) estimate a dynamic model of occupational choice and confirm that students enroll in engineering programs in greater numbers when wages for engineers are higher. However, the literature has not addressed how and to what extent co-op participation in engineering is influenced by job market conditions. This paper contributes to the literature by showing that students are less likely to participate in an engineering co-op program during periods when wage growth in their field is high.

Method

Data

Transcript data for engineering students at the seven universities used in this study were obtained from the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD). The complete MIDFIELD data include the academic records of all degree-seeking undergraduate students from 11 public institutions from 1987 through 2014, though not all institutions provide data for the entire period (Long and Ohland 2015; Ohland et al. 2015). These institutions have larger engineering enrollments than average compared to the approximately 400 colleges with engineering programs in the U.S. Not all the universities in the MIDFIELD data record co-op participation on the student transcript, so the authors restricted data analysis to the seven universities where co-op participation is reported: Clemson University, Florida A&M University and Florida State University (which have a joint College of Engineering), North Carolina State University, Purdue University, University of Florida, and Virginia Tech. With the exception of Purdue University, all of these universities are located in the southeast United States and the authors made no attempt to weight the data to make it more nationally representative.

Table 1. Summary Statistics, Engineering Students Who Are Co-op Participants

Variable	Observations	Mean	SD	Minimum	Maximum
Average wage ($10,000)	6,713	5.206	0.470	4.089	7.009
First-year GPA	6,708	3.371	0.408	2.5	4
High school GPA percentile	5,299	76.51	20.26	1	99
SAT math score	4,916	654.0	64.9	410	800
Female	6,713	0.211	0.408	0	1
White	6,713	0.858	0.349	0	1
African American	6,713	0.032	0.177	0	1
Hispanic	6,713	0.022	0.147	0	1
Asian	6,713	0.059	0.235	0	1

Note: The data include students with a 2.5 freshman-year GPA or higher that have declared a major in chemical, electrical, civil, or materials engineering by the first semester of their sophomore year at Clemson, Florida A&M, Florida State, North Carolina State, Purdue, Florida, and Virginia Tech.

Each of the universities in the sample has a voluntary co-op program where participation is not required for graduation. Because co-op programs have minimum GPA requirements (which may differ by institution and year and for which complete records are not available), the authors restricted the sample to students with a 2.5 cumulative GPA or greater in the first semester of the sophomore year. Students who completed their first year of college after 2005 and all transfer students are excluded from the sample. The sample contains the complete academic records for 29,644 undergraduate students that continued pursuing a degree in engineering after completing their first year of college.

Across all institutions and years, 23% of engineering students in the sample opted to participate in a co-op experience. There is a large amount of variation in participation over time with a high of 33% and a low of 13%. There is even larger variation across institutions with a high of 37% participation and a low of 2% participation.

Tables 1 and 2 report summary statistics for co-op participants and nonparticipants, respectively. These tables show that students who participate in the co-op program have a higher first-year GPA on average than nonparticipants. This indicates disproportionate selection of high-ability students into co-op programs. The higher average SAT math score for co-op participants is additional evidence of positive selection by ability into the co-op program. The summary statistics also indicate that African American students are much less likely to participate in the co-op program than Hispanic, Asian, or White students. Male and female students participate at rates consistent with their representation in the engineering student population.

The MIDFIELD data only gives academic records with no information about job placement or wages. The authors obtained annual field-specific salary data from the American Association of Engineering Societies (AAES) *Annual Report of Engineering Salaries* for each year from 1988 to 2009 (Engineering Workforce Commission 1988–2009). The AAES is the umbrella organization for engineering societies in the United States and conducts an

Table 2. Summary Statistics, Engineering Students Who Are Co-op Nonparticipants

Variable	Observations	Mean	SD	Minimum	Maximum
Average wage ($10,000)	22,931	5.295	0.542	4.089	7.009
First-year GPA	22,902	3.236	0.430	2.5	4
High school GPA percentile	13,056	79.46	18.73	1	99
SAT math score	16,901	646.7	71.8	290	800
Female	22,931	0.214	0.410	0	1
White	22,931	0.749	0.434	0	1
African American	22,931	0.101	0.301	0	1
Hispanic	22,931	0.034	0.180	0	1
Asian	22,931	0.061	0.239	0	1

Note: The data include students with a 2.5 freshman-year GPA or higher that have declared a major in chemical, electrical, civil, or materials engineering by the first semester of their sophomore year at Clemson, Florida A&M, Florida State, North Carolina State, Purdue, Florida, and Virginia Tech.

annual salary survey of more than 100,000 engineers in the private sector and government. The data were not available to the authors electronically, so the data were hard-coded from printed reports. The average wage as well as the upper decile, upper quartile, median, lower quartile, and lower decile are reported for each year by field and by the number of years since undergraduate graduation.

The AAES survey of engineering wages is nationally representative, but the students in the sample are not. Even if location-specific engineering wage data were available, it is not clear if it should be used as many of the graduates are offered jobs located outside the state and often outside the region.

Model and Empirical Specification

The authors modeled students as facing a one-shot decision to participate in a co-op. Students that decide to participate in a co-op generally delay graduation by one year, but face improved job prospects. Each student is assumed to have expectations of the likely future income path if not participating in the co-op program (Y_{it}^0), and another (assumed higher) expected future income path if participating (Y_{it}^1). It was assumed that individual student utility in period t is proportional to the log of student consumption in that period and there is no savings so that individuals consume their earnings in each period. Normalizing the price of consumption to one, the expected present discounted value of utility for student i is given by

$$u_i^0 = \sum_{t=1}^{N} \delta^t E[U(Y_{it}^0)] \tag{1}$$

if the student decides against participating in a co-op. If the student chooses to participate in a co-op, the expected present discounted value of the student's utility is given by

$$u_i^1 = \alpha_i + \sum_{t=2}^{N} \delta^t E[U(Y_{it}^1)] \tag{2}$$

where α_i = utility from the year spent participating in the co-op. The rate of time preference is δ. The individual differences in expected income paths are contained in Y_{it}, which incorporates individual differences in the expected probability of employment in each period. Individuals will chose to participate in a co-op if $u_i^1 > u_i^0$.

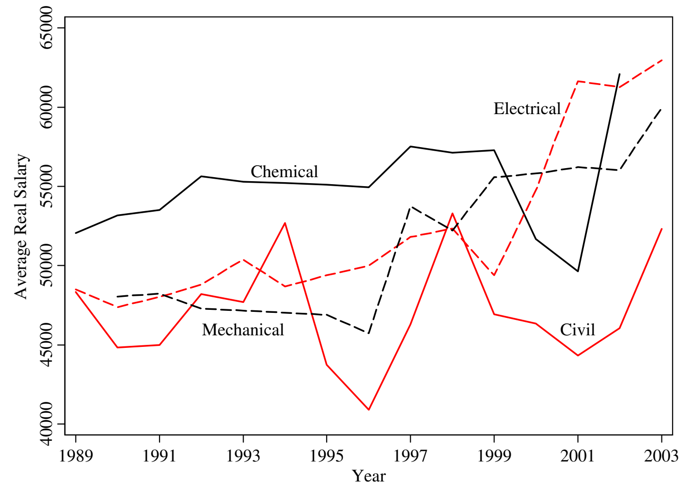

Fig. 2. 5-year real average salary by year [Note: The five-year average salary is computed as described in the text using data from the American Association of Engineering Societies *Annual Report of Engineering Salaries* from each year (Engineering Workforce Commission 1988–2009); the consumer price index for all urban consumers is used to convert reported salaries into 2010 dollars]

The current wages of engineers who recently graduated in the same field likely have a strong influence on the expected future wages for engineering students. An increase in the field-specific average wage signals a good job market for students in that engineering field, which reduces the advantages of co-op participation, driving Y_{it}^1 and Y_{it}^0 closer together. A good job market means that students are more likely to find a job and can expect higher wages even without having participated in the co-op program.

The authors used the AAES salary data to form a year- and field-specific measure of average wages. The discounted mean wage reported was averaged for engineers who received their undergraduate degree within the last five years according to

$$\text{Wage}_{jt} = \frac{1}{6}\sum_{x=0}^{5} (0.95)^{x-1} W_{jtx} \tag{3}$$

where W_{jtx} = average real wage in field j for experience level x and year t. The assumption that future wages are discounted using a rate of about 5% is arbitrary, though the results are robust to alternative assumptions. The resulting variable Wage_{jt} measures the field-specific wage for recently-graduated engineers by year and is the primary explanatory variable of interest. Fig. 2 displays this five-year average real wage for selected fields from 1989 to 2003.

Because the co-op participation variable Coop_{ijkt} is binary, a latent-variable model of co-op participation was estimated using a probit specification:

$$\text{Coop}_{ijkt}^* = \alpha + \beta \text{Wage}_{jt} + \mathbf{X}_{ijkt}\boldsymbol{\gamma} + \boldsymbol{\theta}_{kj} + \boldsymbol{\delta}_t + \eta_{ijkt} \tag{4}$$

where i = individual; j = field; k = university; and t = year. Individual characteristics of student i are given by $\mathbf{X}$. There is potential concern that students differ in unobservable ways that are correlated with which university they attend and which engineering field they choose to study. This was addressed by adding field-by-institution fixed effects, denoted in the model as $\boldsymbol{\theta}_{kj}$. Year fixed effects $\boldsymbol{\delta}_t$ are also included to control for common shocks including aggregate trends in engineering salaries and co-op participation. There are a total of 17 year indicator variables and 38 field-by-institution indicator variables included in the probit model. With the inclusion of these fixed effects, identification comes from field-specific movement in wages and not wage changes that are common to all fields. Standard errors are clustered at the institution level.

Even with time and institution-by-field fixed effects, there is concern that the measure of the average wage for recent engineering graduates is endogenous. The observed co-op participation variable indicates both that the student desired a co-op position and that a co-op employer hired the student. Employers may respond to a wage increase by hiring more co-op students as substitutes for hiring more-expensive permanent employees, or employers may respond to a wage increase by hiring fewer co-op students because they anticipate being able to make fewer job offers at the completion of the co-op program. If the former is true that the estimate of β will be biased upward. If the latter is true, then the estimate of β will be biased downward. To investigate these possibilities, interviews were conducted with co-op employers. Completed interviews suggest that the number of co-op positions offered is not driven by market conditions, which supports the assumption that changes in the number of student participants is driven by student choices rather than employers.

Co-op Employer Interviews

This study's identification of the student co-op participation response to a change in the field-specific wage depends on the assumption that student participation is not constrained by changes to the number of co-op positions available. If, for example, firms reduce the number of co-op positions during periods of slow wage growth, then the estimates may be biased. University co-op offices have reported that employers are able to fill most of their open co-op positions in some years, but that in other years they complain that they cannot find enough qualified students. The authors were unable to obtain data documenting the number of open positions by year or the number of students who applied for the program. If employers do not adjust the number of co-op positions significantly from year to year, periods of excess demand (with many unfilled co-op positions) and periods of excess supply (with many unmatched students) would be due to the student response alone. To confirm this, interviews were conducted with co-op employers and some evidence was found that supports the identification.

The authors conducted interviews with three company representatives involved in co-op recruiting with the intent to evaluate the demand side of the co-op process and specifically to discuss co-op hiring practices in relation to labor market dynamics. Through coordination with the Cooperative Education Program at Clemson University, three companies were identified that have recruited engineering co-op students at Clemson during the period of the study. Representatives at the three companies held positions that coordinated directly with one or more academic institutions and were responsible for determining the number of annual co-op requisitions. Each representative was contacted via email and asked to voluntarily participate in an interview related to the study. Semistructured interviews were performed with company representatives via phone.

The interview protocol included a series of open-ended questions related to the study. A complete copy of the protocol is included in the Appendix. Phone interviews were conducted and lasted 30–60 min. For consistency, all interviews were conducted by the same author. Recorded interviews were transcribed and proofed against the original recordings, and the recordings were subsequently destroyed. The names of companies and company representatives that participated in this study are intentionally not included in reporting.

The representative from Company 1, a regional employer in the energy sector, reported that the number of co-op positions offered had increased from 250 to 400 over the prior 3 years. The representative stated that the co-op program was a "mess" 3 years before and that it was growing out of a desire to make more full-time hires from the pool of co-op participants. The representative also suggested that they should use the co-op program to smooth out bumps in full-time hiring, though with only 3 years of co-op program data available to the representative, it was not clear if employment smoothing was occurring.

The representative from Company 2, a large international employer in the chemical and manufacturing sectors, reported that co-op hiring had been constant at between 100 and 150 positions each year over the past 10 years. The representative reported that they had never experienced any trouble filling all their co-op positions and stated that the decision to hire about the same number of co-op students each year improves their reputation with the students at universities where they do their recruiting.

The representative from Company 3, a large international employer in multiple engineering-related sectors, reported that they hire about 500 co-op students each year and that they do not deviate by more than 10% in the total number of co-op positions in any given year. The representative reported that they have far more co-op applications during periods with a poor engineering job market (low wages), but that they do not adjust the number of co-op positions.

Company 2 and Company 3 draw a significant percentage of their full-time, permanent hires from the co-op population and view their co-op students as the entry point to a pipeline of full-time candidates. Company 3 reported that as much as 80% of their annual full-time hiring comes from prior co-op and internship positions. Accordingly, Company 3 advertises their co-op positions as the preferred path towards full-time employment and they maintain rigorous standards for securing a co-op position. Alternatively, Company 1 may have hired co-op students to help even-out fluctuations in full-time hiring rather than as a pipeline towards full-time employment, though Company 1 seemed to be transitioning to a larger co-op program.

These interviews suggest that the number of co-op positions is fairly constant over time. Firms seem hesitant to reduce the number of co-op positions they make available each year because they want to have a good reputation with the university co-op programs and students they are trying to recruit. Though none of the companies interviewed said they ever had trouble filling their open co-op positions, co-op program offices have indicated that this sometimes occurs.

Results

The authors estimated a probit model where Eq. (4) is the underlying latent variable model. The marginal effects evaluated at the mean are reported in Table 3. The included control variables were varied over the first four columns, though the year and field-by-institution fixed effects are included in every specification. Table 3 indicates that the estimated effect of a change in the average real wage on the probability of co-op participation is robust to the inclusion of gender, race, and GPA controls. The interpretation of the estimate is that a \$10,000 real increase in the field-specific average real wage, as defined by Eq. (3), causes a 5.4 percentage-point decrease in the probability of co-op participation. The baseline probability of co-op participation is 22.6% in the sample so a \$10,000 real increase in the wage is estimated to cause a 24% decrease in co-op participation.

While a large wage change was used in reporting the regression results, the AAES wage data shows that annual real wage changes

Table 3. Estimated Marginal Effects from a Probit Model of Co-op Participation

Variable	(1)	(2)	(3)	(4)
Average wage ($10,000)	−0.056[a] (0.020)	−0.056[a] (0.020)	−0.054[a] (0.020)	−0.054[a] (0.020)
Female	—	0.008 (0.023)	0.012 (0.020)	0.010 (0.020)
International student	—	—	−0.021 (0.018)	−0.023 (0.020)
Asian	—	—	−0.002 (0.022)	−0.004 (0.021)
African-American	—	—	−0.083[a] (0.021)	−0.070[a] (0.022)
Hispanic	—	—	0.020 (0.022)	0.023 (0.022)
Other race	—	—	−0.050[a] (0.019)	−0.053[b] (0.025)
Freshman GPA	—	—	—	0.098[a] (0.027)
Observations	29,625	29,625	29,625	29,591
Pseudo R-squared	0.1211	0.1212	0.1237	0.1342

Note: All specifications include year fixed effects and university-by-major fixed effects. Standard errors clustered at the institution level are given in parentheses.
[a]$p < 0.1$.
[b]$p < 0.01$.

in engineering fields are much smaller. The median annual change in the wage measure as defined in Eq. (3) for all fields from 1988 to 2009 is only $430. Estimates imply that a real wage change of this size would cause a 0.23 percentage point decrease in the probability of co-op participation, a 1% reduction.

The results reported in Table 3 indicate that female students are not significantly more likely to participate in a co-op program than male students. However, African American students are much less likely to participate than White students. This is true even with institution fixed effects and after controlling for GPA. The representative from Company 3 mentioned that they often had trouble meeting their diversity goals in their co-op recruiting, suggesting that fewer African American students apply for co-op positions.

The results also indicate that high ability students (those with higher GPA) are more likely to participate in a co-op program. The disproportionate selection of high-ability students into co-op programs suggests that estimates, like those from Somers (1995), showing that co-op participants are more likely to find employment and receive higher wages are likely biased upwards. It is the authors' view that the co-op program improves (but delays) the labor market outcome on average for participating students, though likely to a smaller magnitude than is estimated in the literature in light of this positive selection.

The model presented suggests that student heterogeneity in future wage expectations accounts for the variation in co-op participation. However, the effect of co-op participation on future wages may itself depend on student ability. This could cause heterogeneity in the effect that a change in the average wage has on the co-op participation decision. When the average wage increases, is it high-ability or low-ability students that primarily turn down co-op participation in favor of earlier graduation?

In Table 4, GPA was used as a measure of student ability and the model for each quartile of the GPA distribution was estimated. The 25th GPA percentile is 2.91, the median GPA is 3.26, and the 75th percentile is 3.63. Recall that the sample was restricted to students with at least a 2.5 GPA at the time they make the co-op decision. Estimates suggest that high-ability students (likely students with the highest future income paths) are least likely to engage in co-op participation in response to an increase in the average real wage.

As reported in Table 4, the estimated effect of a change in the average wage is similar for students in the lower 75% of the GPA distribution, but much smaller in magnitude and not statistically different than zero for those in the highest GPA quartile. This suggests that high-ability students do not change their co-op participation decision in response to job market conditions. The authors predict that a large increase in the real wage would decrease the number of low-ability students who choose to participate in a co-op program, but would leave the number of high-ability participants unchanged.

In terms of the model, if nonparticipating high-ability students face little risk of lower job market prospects due to a worse labor market, they would not be induced to participate if the average real wage were to decrease. However, if lower-ability students believe they are able to improve their job market outcome by participating in a co-op program, their participation should increase when the average real wage decreases. The results from Table 4 are consistent

Table 4. Estimated Marginal Effects from a Probit Model of Co-op Participation by Ability Level

Variable	(1) GPA < 2.91	(2) GPA (2.91–3.25)	(3) GPA (3.26–3.63)	(4) GPA > 3.63
Average wage ($10,000)	−0.069[a] (0.014)	−0.071[a] (0.026)	−0.066[a] (0.024)	−0.019 (0.027)
Female	0.009 (0.018)	0.035[b] (0.019)	0.009 (0.022)	−0.008 (0.028)
International student	−0.014 (0.022)	−0.006 (0.031)	−0.032[a] (0.007)	−0.034[b] (0.020)
Asian	0.019 (0.033)	−0.005 (0.029)	−0.002 (0.016)	−0.032[c] (0.015)
Black	−0.037[a] (0.009)	−0.091[a] (0.034)	−0.089[a] (0.020)	−0.090[b] (0.050)
Hispanic	0.095[c] (0.044)	0.005 (0.063)	−0.014 (0.011)	0.006 (0.050)
Other race	−0.011 (0.017)	−0.061 (0.058)	−0.044[c] (0.022)	−0.079[a] (0.015)
Observations	7,119	7,107	7,433	7,339
Pseudo R-squared	0.1089	0.1235	0.1400	0.1228

Note: All specifications include year and university-by-major fixed effects. Standard errors clustered at the institution level are given in parentheses.
[a]$p < 0.01$.
[b]$p < 0.1$.
[c]$p < 0.05$.

with this interpretation, though no direct evidence is available that job market outcomes are affected by co-op participation.

Conclusions

This paper estimates the response of co-op participation to the engineering field-specific average wage for recent graduates. The authors found no evidence that high-ability student participation in the engineering co-op program is influenced by the engineering job market. However, strong evidence was found that at times when average wage growth is low (or even negative) and it is likely more difficult to secure a job after graduation, the co-op participation rate of lower-ability students increases dramatically. Interviews with employers of co-op students suggest that this is primarily a student-driven response.

This study's findings have real implications for engineering education and the management of co-op programs. The significant sensitivity of co-op participation to wage changes implies that co-op program administrators and co-op employers will find current job market conditions useful in forecasting co-op participation. Though the identification comes from field-specific wage variation, findings suggest that an important explanation for the decline in the overall popularity of co-op programs in the late 1990s through the end of data in 2005 is the good job market conditions for engineers during that period.

This study's finding that the participation of high-ability students is not affected by job market conditions suggests a puzzle. That high-ability students do not respond to changes in the average wage could suggest that their co-op participation decision is not heavily influenced by the expected difference in future wages. If this is the case, then what explains the high rate of participation by high-ability students? About 29% of students in the top 25% of the GPA distribution at the time they make the co-op participation decision choose to participate while only about 20% of students in the lower 75% of the GPA distribution choose to participate. Since high-ability students are not affected by job market conditions, this may mean that they choose to participate based on other benefits as they are articulated by co-op program recruiting efforts. Co-op directors might benefit from exploring the extent to which high-ability students are aware of the program—particularly in years when job market conditions are good and co-op participation from lower-ability students would be expected to decline.

Another puzzle is the finding that African American students are underrepresented among co-op students. Because co-op participation involves semesters of full-time employment at wages that are higher than average student wages, one might anticipate that students from low-income backgrounds would be more likely, not less likely to participate in a co-op program. For low-income students, a co-op program could be a way to pay for college. For a subset of the data, the authors observed the zip code of the student and found that the African American students live in zip codes with nearly $10,000 lower median household income than all other students in the data. If African American students come from lower-income families, why are they less likely to participate in a co-op? Whatever the explanation, the results suggest that companies that recruit through co-op programs will have more difficulty in achieving their diversity goals than companies that do not recruit through co-op programs.

Appendix. Phone Interview

The phone interviews followed the following script:

We are performing research related to engineering cooperative education hiring practices in relation to labor market dynamics. It is our understanding that your company regularly hires cooperative education engineering students. You have been identified as the appropriate person at your company to speak with regarding this subject. However, if you cannot answer some of these questions, please let me know and we can discuss who might be a better contact for your company. Of course, if you wish to not answer a particular question or wish to end the interview at anytime, please let me know.

Thank you for your time and willingness to participate in this study.

Are you ready to begin?
Name:
Company:
Title:
Length of time in that position:
Please describe your involvement (both currently and previously) in the process of identifying and hiring engineering cooperative education students for your company?
At which academic institutions do you have personal experience in recruiting from?
Are you aware of your company's active recruiting of other academic institutions? If yes, which academic institutions?
During your interaction with engineering cooperative education students, have you noted any trends in the level of personal and professional preparation of the students?
Have you noted any trends in the number of students applying for engineering cooperative education positions at your company?
Typically, what is the total number of engineering cooperative education positions at your company and what is the common length of employment for those positions?
Have you noted any trends in the number of engineering cooperative education positions available at your company?
Have you noted any relationships between unemployment/economic conditions and the number of engineering cooperative education positions available at your company?
Have you noted any relationships between unemployment/economic conditions and the number of engineering cooperative education students applying for positions at your company?
If you perceive that there has been a decline in the number of engineering cooperative education positions and/or applicants for those positions, what do you attribute that to?
How could cooperative education programs do a better job of ensuring that there are a sufficient number of qualified applicants applying for engineering cooperative education positions?
Are there any further thoughts you have related to engineering cooperative education that you would like to share?

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